



On-Orbit, Subarcsecond Pointing of the 6U ASTERIA CubeSat

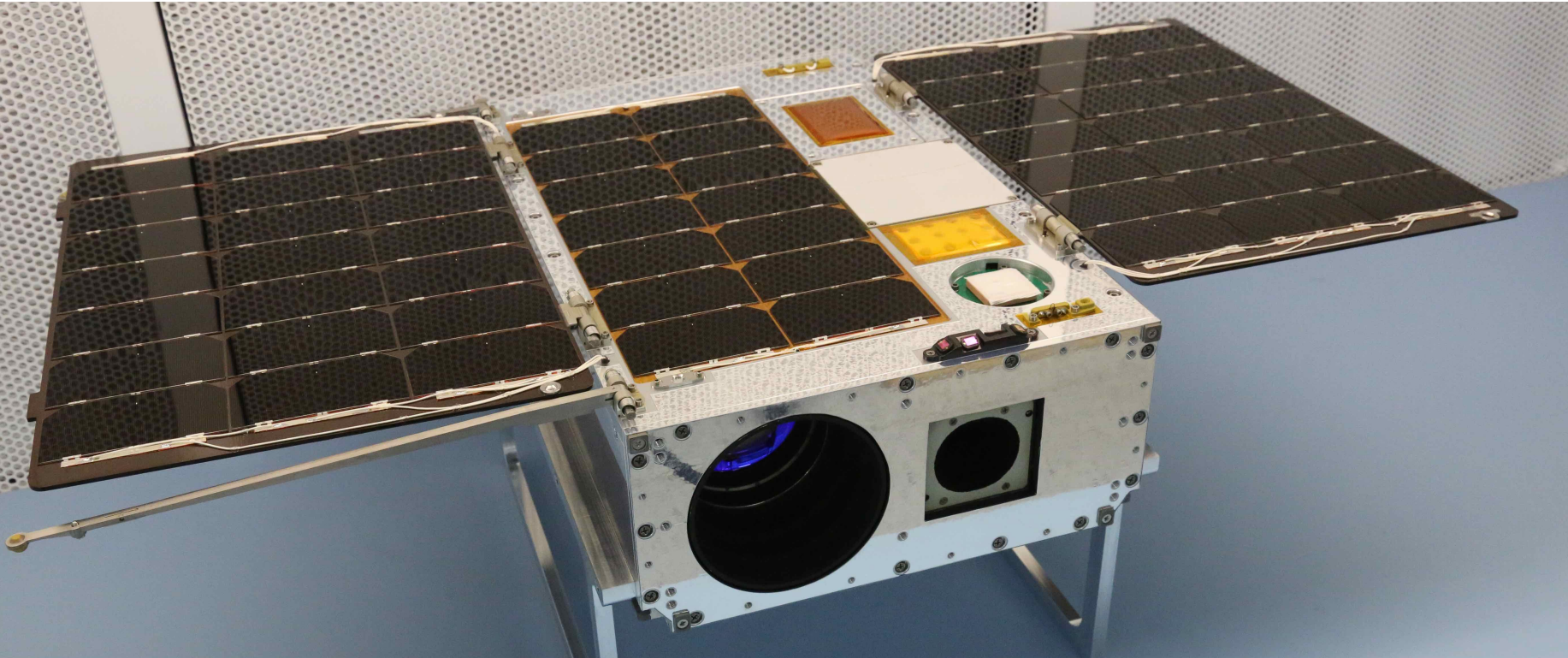


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8 August, 2018

ASTERIA Overview

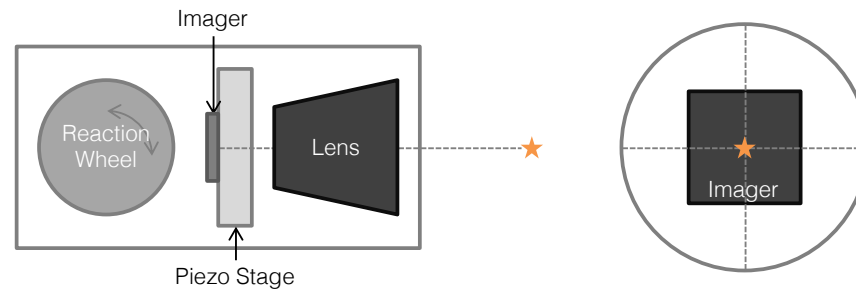
Arcsecond Space Telescope Enabling Research in Astrophysics



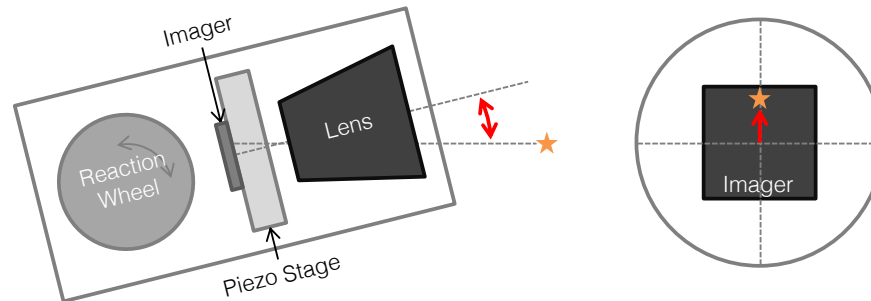
- 6U CubeSat (11 cm x 24 cm x 37 cm, 10 kg)
- Designed, built, tested, operated at JPL; science team at MIT and U. Bern
- Deployed from ISS (400-km altitude, 51.6-deg inclination)

Perform photometry on bright stars, which requires repeatable and stable pointing

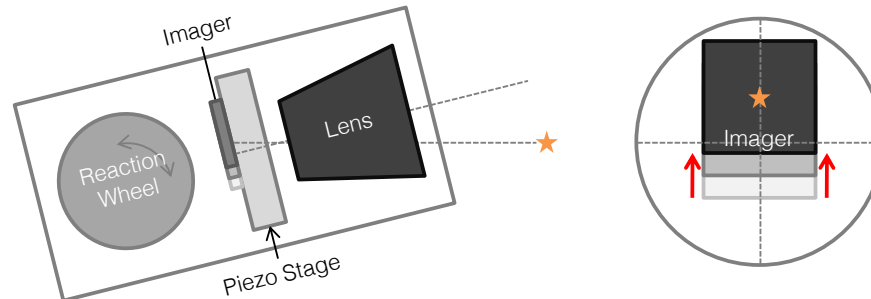
Pointing Control Approach



Reaction wheels point the spacecraft to the target star



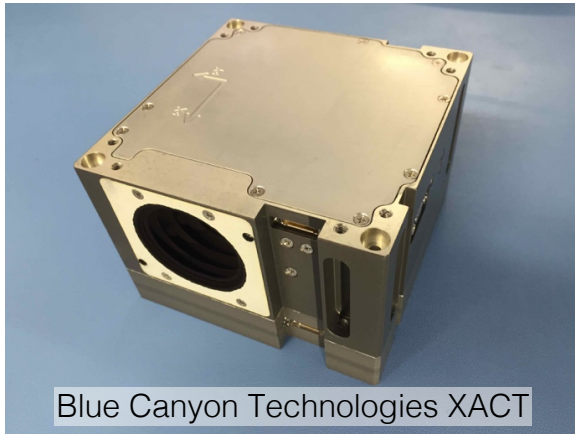
Attitude errors will cause the target star to shift on the imager



Piezo stage shifts the imager to compensate for attitude errors

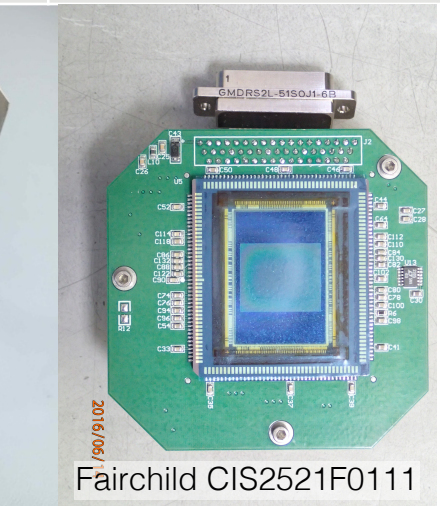
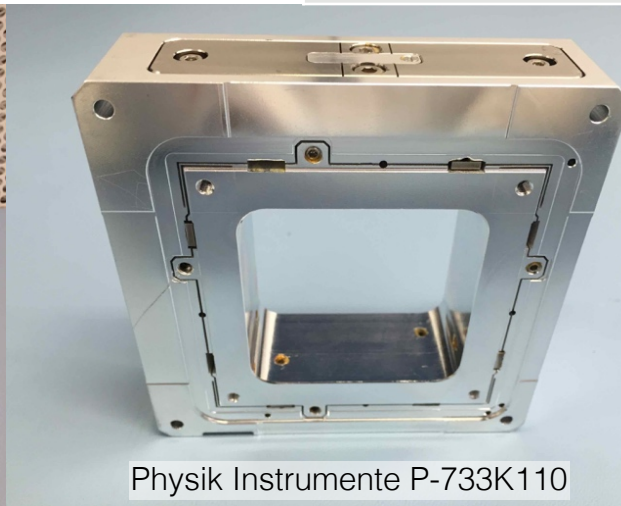
Two-stage control architecture: Reaction wheels and piezo stage

Pointing Control Hardware



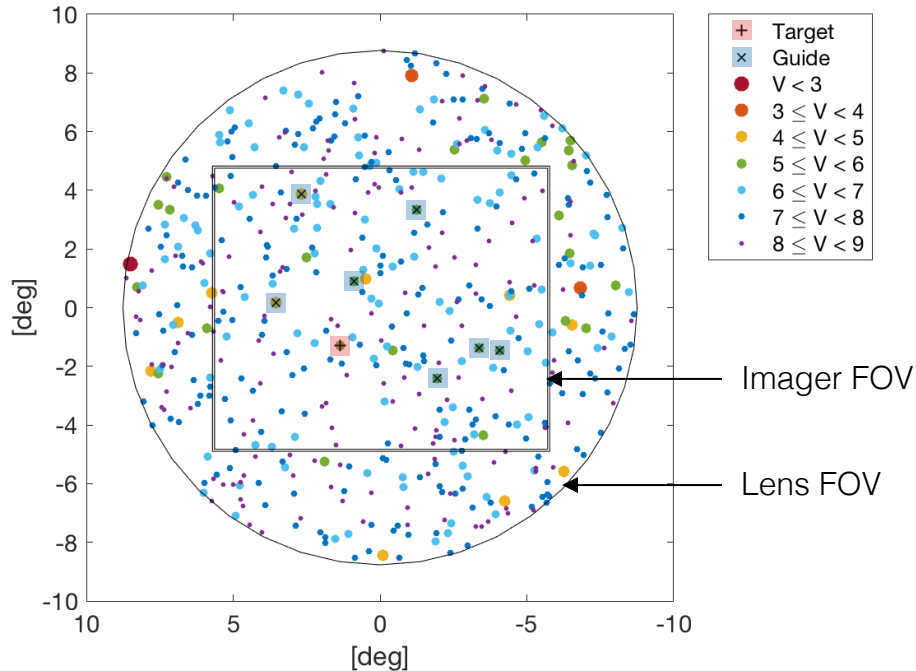
- Contains:
- Reaction wheels
 - Torque rods
 - Star tracker
 - Gyros
 - Sun sensor
 - Magnetometer

Payload Parameter	Value
Focal length	85 mm
Aperture diameter	60.7 mm (f/1.4)
Format	2592 pix x 2192 pix
Pixel size	6.5 μm x 6.5 μm
Field of view	11.2 deg x 9.6 deg
Plate scale	15.8 arcsec/pix
Piezo stroke	100 μm (240 arcsec)

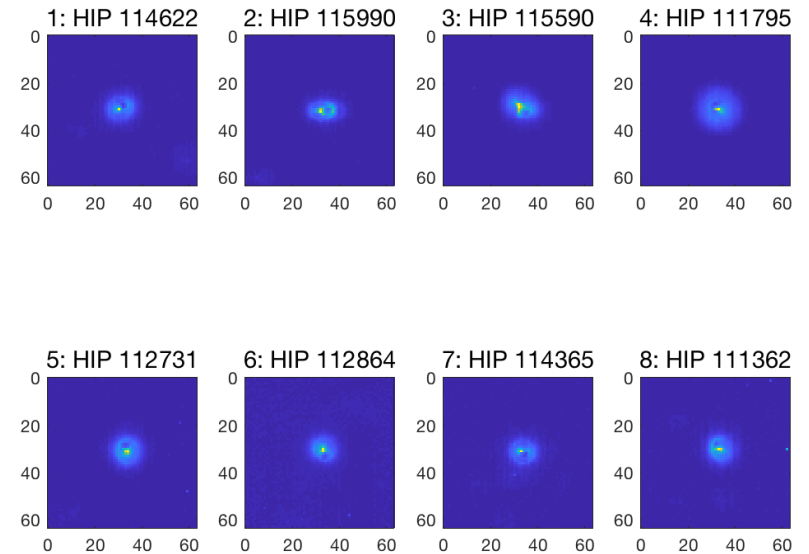


Uses a combination of COTS and customized hardware

Focal Plane Array Layout



Target and guide star windows on focal plane array



Windowed images of target and guide stars

Windowed images provide sensor feedback for the pointing control loop

The diagram illustrates the control system architecture for the XACT instrument, showing the flow of data and control signals between various components.

Central Components:

- Pointing Control** (Blue box)
- Target Star Centering** (Blue box)
- Piezo & Roll Offload** (Blue box)
- Centroiding** (Blue box)

Actuators and Sensors:

- Piezo Stage** (Orange box)
- Piezo Stage Strain Gauges** (Green box)
- XACT** (Orange box)
- Imager** (Green box)

Software and Actuator Stack:

- Actuators** (Orange box)
- Sensors** (Green box)
- Software** (Blue box)

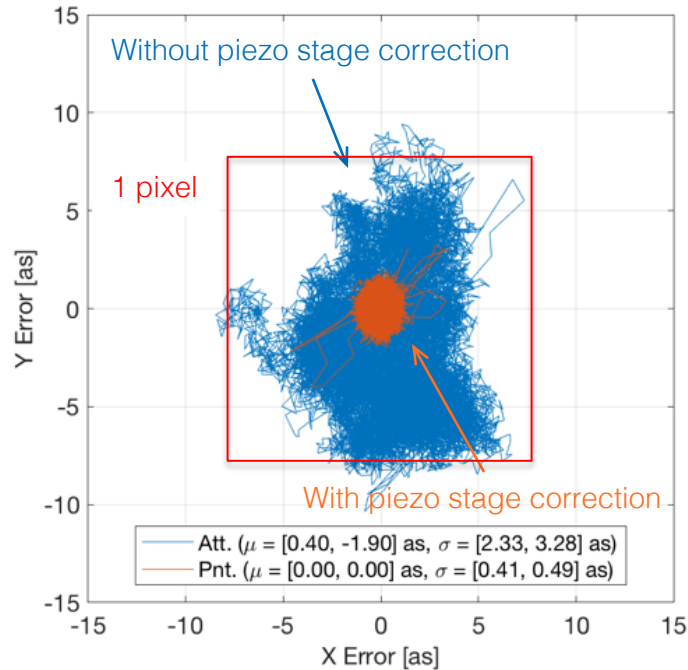
Data Flow and Signals:

- Cmd. Centroids** (Input to Pointing Control)
- Cmd. Target Centroid** (Input to Target Star Centering)
- Offset** (Signal from Target Star Centering to Pointing Control)
- Meas. Pos.** (Signal from Piezo Stage Strain Gauges to Target Star Centering)
- Cmd. Pos.** (Signal from Pointing Control to Piezo Stage)
- Cmd. Quat.** (Signal from Piezo & Roll Offload to XACT)
- Win. Imgs.** (Signal from Imager to Centroiding)
- Centroids** (Signal from Centroiding to Centroiding)

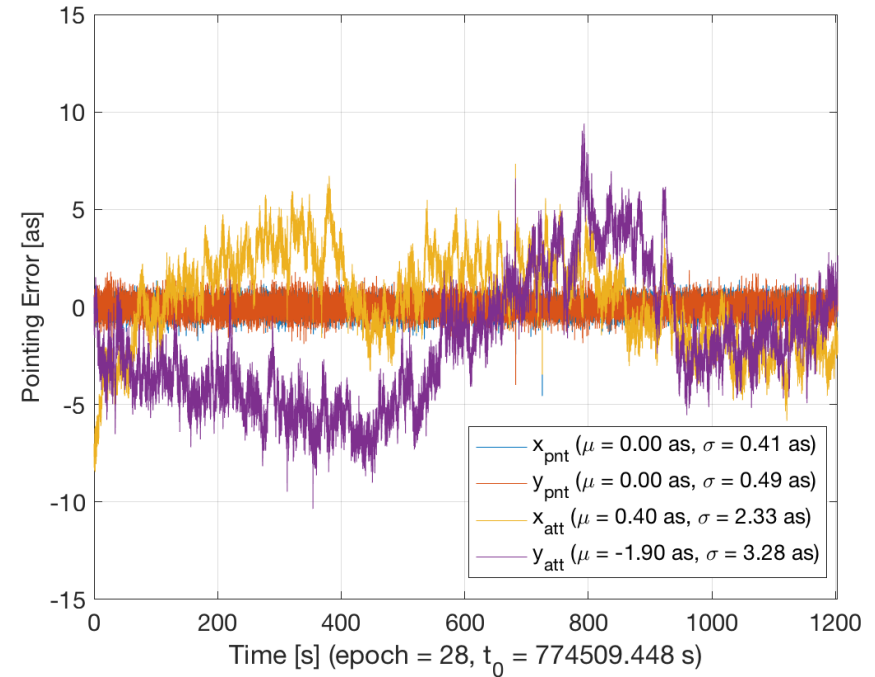
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Pointing Control Results

Pointing Error over 20 Minutes

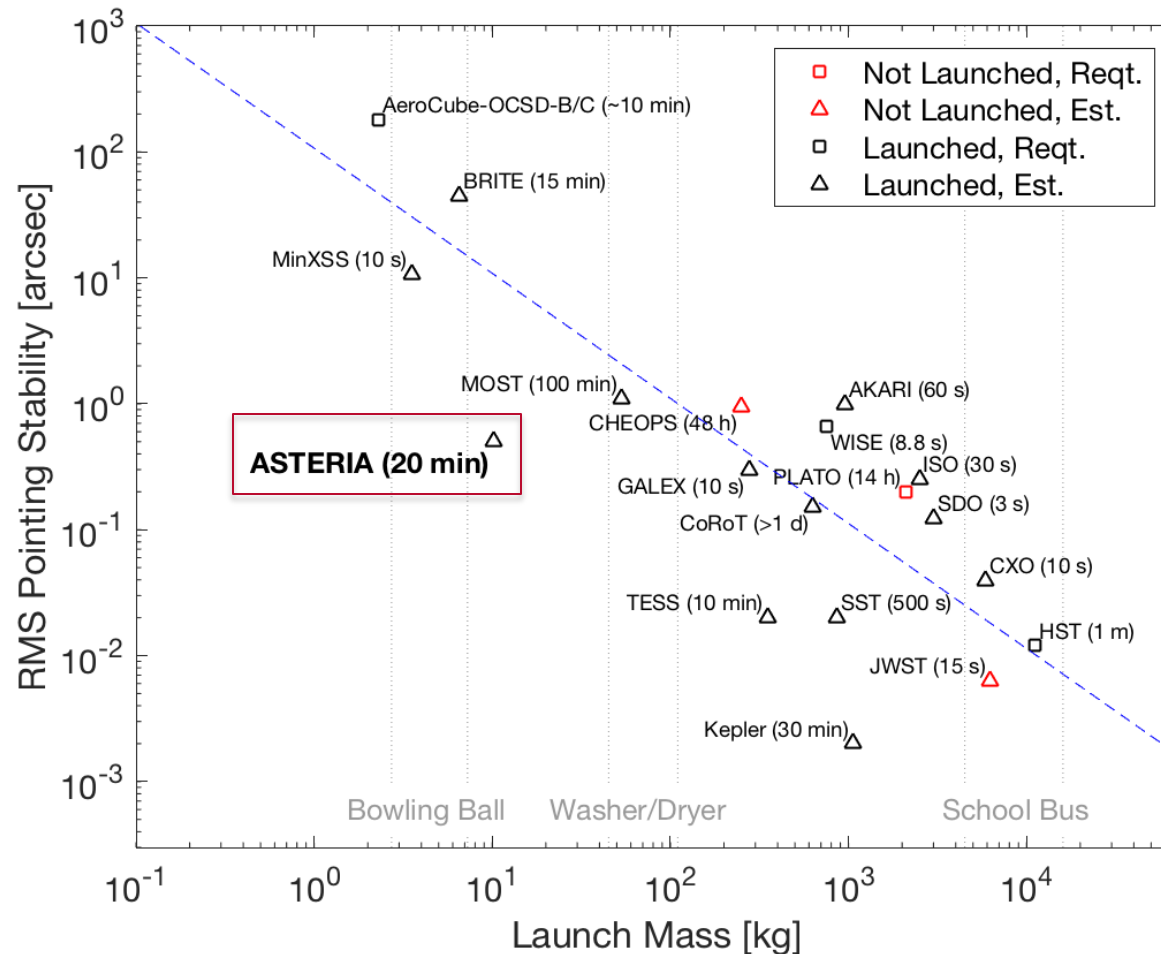


Pointing Error versus Time



Repeatability: 1 mas RMS from observation to observation
Stability: 0.5 arcsec RMS over 20-minute observations

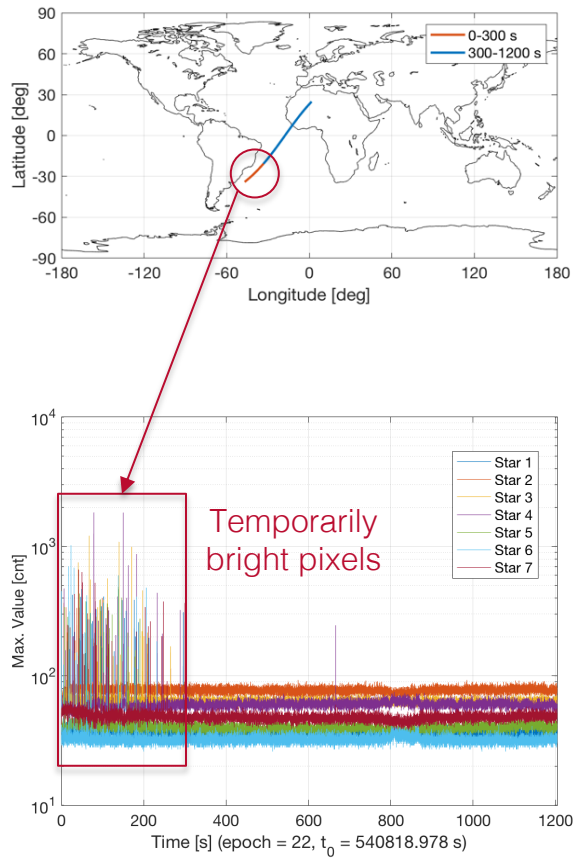
Pointing Stability Comparison



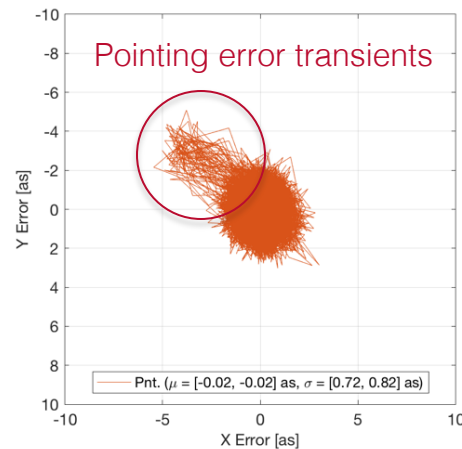
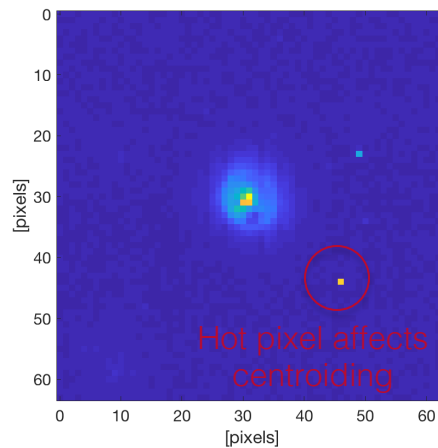
Achieved the best pointing performance to date versus spacecraft of similar size

Pointing Issues Encountered

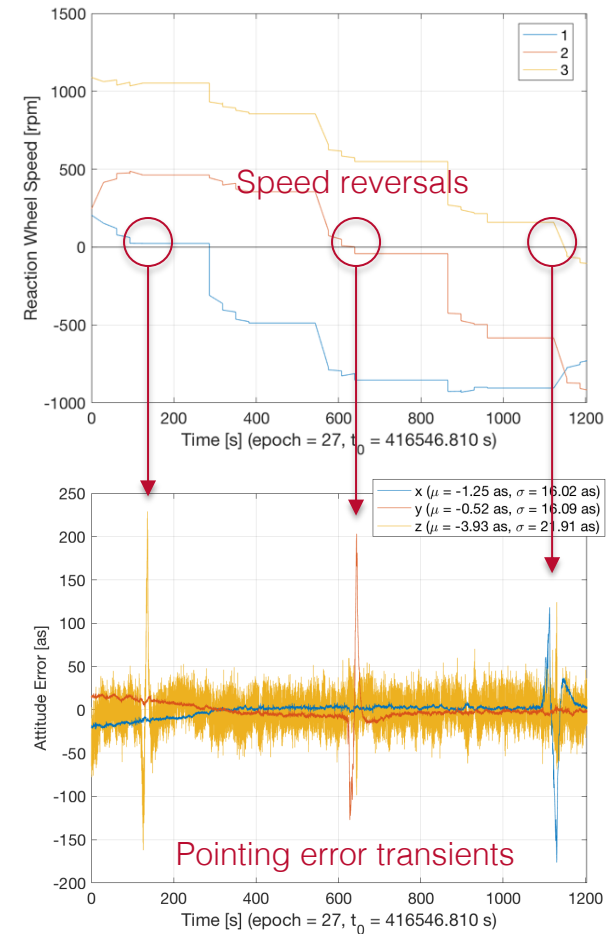
Temporarily Bright Pixels in South Atlantic Anomaly



Hot Pixels



Reaction Wheel Speed Reversals



Various pointing issues were encountered and workarounds were developed

For More Information

- Pong, C. M., “On-Orbit Performance & Operation of the Attitude & Pointing Control Subsystems on ASTERIA,” *32nd Annual AIAA/USU Conference on Small Satellites*, Logan, UT, August 2018, pp. 1–20.
- Smith, M. W., Donner, A., Knapp, M., Pong, C. M., Smith, C., Luu, J., Di Pasquale, P., Bocchino, R. L., Jr., Campuzano, B., Loveland, J., Colley, C., Babuscia, A., White, M., Krajewski, J., Seager, S., “On-Orbit Results and Lessons Learned from the ASTERIA Space Telescope Mission,” *32nd Annual AIAA/USU Conference on Small Satellites*, Logan, UT, August 2018, pp. 1–20.



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